2. ECN Category (mark one)		3. Originator's Name, Organization, MSIN, and Telephone No.	4. USQ Required?	5. Date
Supplemental		J. G. Field, LMHC, R2-12 376-3753	[] Yes [X] No	08/26/97
Direct Revision	X			
Change ECN	[]	6. Project Title/No./Work Order No.	7. Bldg./Sys./Fac. No.	8. Approval Designator
Temporary	[]			
Standby	[]	Tank 241-U-109	NA	NA
Supersedure	[]			
Cancel/Void	[]	9. Document Numbers Changed by this ECN (includes sheet no. and rev.)	10. Related ECN No(s).	11. Related PO No.
		WHC-SD-WM-ER-609, Rev. 0	NA	NA

12a. Modification Work	12b. Work Package No.	12c. Modification Work Complete	12d. Restored to Original Condition (Temp. or Standby ECN only)
[] Yes (fill out Blk. 12b) [X] No (NA Blks. 12b, 12c, 12d)	NA	NA	NA
		Design Authority/Cog. Engineer Signature & Date	Design Authority/Cog. Engineer Signature & Date

13a. Description of Change   13b. Design Baseline Document? [] Yes [X] No

Add Appendix D, Evaluation to Establish Best-Basis Inventory for Single-Shell Tank 241-U-109.

14a. Justification (mark one)

Criteria Change	[]	Design Improvement	[]	Environmental	[]	Facility Deactivation	[]
As-Found	[X]	Facilitate Const	[]	Const. Error/Omission	[]	Design Error/Omission	[]

14b. Justification Details

An effort is underway to provide waste inventory estimates that will serve as standard characterization source terms for the various waste management activities. As part of this effort, an evaluation of available information for single-shell tank 241-U-109 was performed, and a best-basis inventory was established. This work follows the methodology that was established by the standard inventory task.

15. Distribution (include name, MSIN, and no. of copies)

Central Files	A3-88	K. M. Hall	R2-12
DOE Reading Room	H2-53	K. M. Hodgson	R2-11
TCSRC	R1-10	B. A. Higley	H4-27
File	H5-49	J. H. Baldwin	R2-12
J. G. Field	R2-12		
M. J. Kupfer	H5-49		
M. D. LeClair (3)	H0-50		

RELEASE STAMP

DATE: HANFORD

STA: 4 RELEASE ID: 2

AUG 28 1997

A-7900-013-2 (05/96) GEF095

A-7900-013-1

| 16. Design Verification Required | 17. Cost Impact | | 18. Schedule Impact (days) |

16. Design Verification Required
[] Yes
[X] No

17. Cost Impact

ENGINEERING

Additional [] $
Savings [] $

CONSTRUCTION

Additional [] $
Savings [] $

18. Schedule Impact (days)

Improvement []
Delay []

19. Change Impact Review: Indicate the related documents (other than the engineering documents identified on Side 1) that will be affected by the change described in Block 13. Enter the affected document number in Block 20.

SDD/DD	[]	Seismic/Stress Analysis	[]	Tank Calibration Manual	[]
Functional Design Criteria	[]	Stress/Design Report	[]	Health Physics Procedure	[]
Operating Specification	[]	Interface Control Drawing	[]	Spares Multiple Unit Listing	[]
Criticality Specification	[]	Calibration Procedure	[]	Test Procedures/Specification	[]
Conceptual Design Report	[]	Installation Procedure	[]	Component Index	[]
Equipment Spec.	[]	Maintenance Procedure	[]	ASME Coded Item	[]
Const. Spec.	[]	Engineering Procedure	[]	Human Factor Consideration	[]
Procurement Spec.	[]	Operating Instruction	[]	Computer Software	[]
Vendor Information	[]	Operating Procedure	[]	Electric Circuit Schedule	[]
OM Manual	[]	Operational Safety Requirement	[]	ICRS Procedure	[]
FSAR/SAR	[]	IEFD Drawing	[]	Process Control Manual/Plan	[]
Safety Equipment List	[]	Cell Arrangement Drawing	[]	Process Flow Chart	[]
Radiation Work Permit	[]	Essential Material Specification	[]	Purchase Requisition	[]
Environmental Impact Statement	[]	Fac. Proc. Samp. Schedule	[]	Tickler File	[]
Environmental Report	[]	Inspection Plan	[]		[]
Environmental Permit	[]	Inventory Adjustment Request	[]		[]

20. Other Affected Documents: (NOTE: Documents listed below will not be revised by this ECN.) Signatures below indicate that the signing organization has been notified of other affected documents listed below.

Document Number/Revision   Document Number/Revision   Document Number Revision

NA

21. Approvals

	Signature	Date		Signature	Date
Design Authority			Design Agent		
Cog. Eng. M. J. Kupfer	_MJKupfer_	8-27-97	PE		___
Cog. Mgr. K. M. Hodgson	_K. M. Hodgson_	8-27-97	QA		___
QA			Safety		___
Safety			Design		___
Environ.			Environ.		___
Other J. H. Baldwin	_B.C. Simpson for J.H. Baldwin_	8-27-97	Other		___

DEPARTMENT OF ENERGY

Signature or a Control Number that tracks the Approval Signature

ADDITIONAL

Tank Characterization Report for Single-Shell Tank 241-U-109

J. G. Field and B. A. Higley
Lockheed Marting Hanford Corporation, Richland, WA 99352
U.S. Department of Energy Contract DE-AC06-96RL13200

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Key Words: TCR, best-basis inventory

Abstract: An effort is underway to provide waste inventory estimates that will serve as standard characterization source terms for the various waste management activities. As part of this effort, an evaluation of available information for single-shell tank 241-U-109 was performed, and a best-basis inventory was established. This work follows the methodology that was established by the standard inventory task.

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Release Approval   Date   8/28/97

Approved for Public Release

	RECORD OF REVISION	(1) Document Number	
		WHC-SD-WM-ER-609	Page 1

(2) Title

Tank Characterization Report for Single-Shell Tank 241-U-109

CHANGE CONTROL RECORD			
(3) Revision	(4) Description of Change - Replace, Add, and Delete Pages	Authorized for Release	
		(5) Cog. Engr.	(6) Cog. Mgr. Date
0	(7) Initially released 09/05/96 on EDT 617522.	J. H. Baldwin	J. G. Kristofzski
RS 0A	Incorporate per ECN-634637.	M. J. Kupfer	K. M. Hodgson
		M.J.Kupfer 8-27-97	*K.M.Hodgson 8-27-97*

APPENDIX D

EVALUATION TO ESTABLISH BEST-BASIS INVENTORY FOR SINGLE-SHELL TANK 241-U-109

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APPENDIX D

EVALUATION TO ESTABLISH BEST-BASIS INVENTORY FOR SINGLE-SHELL TANK 241-U-109
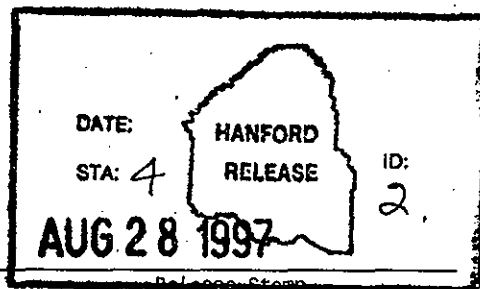
An effort is underway to provide waste inventory estimates that will serve as standard characterization source terms for the various waste management activities (Hodgson and LeClair 1996). As part of this effort, an evaluation of available information for single-shell tank 241-U-109 was performed, and a best-basis inventory was established. This work, detailed in the following sections, follows the methodology that was established by the standard inventory task.

The following evaluation provides a best-basis inventory estimate for chemical and radionuclide components in tank 241-U-109.

D1.0 CHEMICAL INFORMATION SOURCES

Appendix A provides characterization results from the December 1995-January 1996 characterization event for tank 241-U-109. Three push mode core samples were obtained. A sample-based inventory was prepared based on the analytical results, a waste density of 1.67 g/mL, and an overall waste volume of 1,753 kL. The Hanford Defined Waste (HDW) model (Agnew et al. 1997a) provides tank contents estimates, derived from process flowsheets and waste volume records.

D2.0 COMPARISON OF COMPONENT INVENTORY VALUES

The sample-based inventory estimate from Appendix A and the inventory estimate from the HDW model (Agnew et al. 1997a) for tank 241-U-109 are shown in Tables D2-1 and D2-2 (the chemical species are reported without charge designation per the best-basis inventory convention). The waste volume used to generate the estimate is 1,753 kL (463 kgal) (Hanlon 1997). The estimates, however, use different waste densities. The sample-based inventory uses a measured bulk density of 1.67 g/mL. The current HDW model uses a waste density of 1.80 g/mL. Although most of the inventory estimates between the two methods are reasonably close, a few significant differences between the sample-based and HDW model inventories are apparent. Estimates obtained from the two methods for Al, and TOC vary by a factor of two or more. Many of the sample analytes were reported as "less than" values and comparison by this criteria is indeterminate.

Table D2-1. Sampling and Hanford Defined Waste Model Inventory Estimates for
Nonradioactive Components in Tank 241-U-109.

Analyte	Sampling inventory estimate[a] (kg)	HDW model inventory estimate[b] (kg)	Analyte	Sampling inventory estimate (kg)	HDW model inventory estimate (kg)
Al	57,700	1.21 E+05	Ni	<1,230	798
Bi	<6,180	499	NO_2	NR	2.42 E+05
Ca	<6,180	3,580	NO_3	9.02 E+05	6.26 E+05
Cl	NR	18,100	OH	NR	4.42 E+05
Cr	10,800	16,200	oxalate	NR	10.5
F	NR	2,230	Pb	NR	2,640
Fe	<4,160	2,760	P as PO_4	<71,700	20,700
FeCN/CN	NR	0	Si	<3,370	4,800
Hg	NR	77.9	S as SO_4	NR	50,500
K	NR	5,400	Sr	NR	0
La	NR	12.6	TIC as CO_3	110,000	68,100
Mn	<632	467	TOC	10,500	29,800
Na	6.47 E+05	7.12 E+05	U_{TOTAL}	1,250[c]	46,700
NH_4	NR	3,081	Zr	NR	39.1
Density (kg/L)	1.67	1.80	H_2O (wt%)	24.0	22.2

HDW = Hanford Defined Waste
NR = Not reported
[a] Appendix A.
[b] Agnew et al. (1997a).
[c] Core composite phosphorescence analysis

Table D2-2. Sampling and Hanford Defined Waste Model Inventory Estimates for Radioactive Components in Tank 241-U-109 (Decayed to January 1, 1994).

Analyte	Sampling inventory estimate[a] (Ci)	HDW model inventory estimate[b] (Ci)
^{90}Sr	20,200	271,000
^{137}Cs	3.28 E+05	5.70 E+05
$^{239/240}Pu$	NR	258
Total α	109	NR

HDW = Hanford Defined Waste.
NR = Not reported.
[a] Appendix A.
[b] Agnew et al. (1997a)

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D3.0 COMPONENT INVENTORY EVALUATION

The following evaluation of tank contents is performed to identify potential errors and/or missing information that would influence the sampling-based and HDW model component inventories.

D3.1 CONTRIBUTING WASTE TYPES

Tank 241-U-109 is the third tank in a cascade series beginning with tanks 241-U-107 and 241-U-108. It first received metal waste from tank 241-U-108 in March 1949 and was full by the third quarter of 1949. Removal of the metal waste started in 1953 and was completed in the first quarter of 1954. New metal waste started entering the tank in the third quarter of 1954 and the tank was full by the fourth quarter of the same year. Metal waste was sluiced from tank 241-U-109 in the second quarter of 1956 and the tank was declared empty (Anderson 1990).

In the third and fourth quarters of 1956, tank 241-U-109 received REDOX cladding waste supernatant. Except for a few additions of water, the tank was inactive until 1969 when most of the waste was sent to 241-TX-118. In the fourth quarter of 1969, supernatant was received from 241-U-107. No further transfers occurred until 1974 when much of the waste was sent to 241-S-110. In the fourth quarter of 1975, tank 241-U-109 received evaporator bottoms from the 242-S Evaporator Crystallizer. In the first quarter of 1977, residual liquor was received. Tank 241-U-109 was declared inactive in the first quarter of 1978.

The current waste volumes for tank 241-U-109 are shown in Table D3-1 (Hanlon 1997). The types of solids accumulated in tank 241-U-109, reported by various authors, is compiled in Table D3-2 and Table D3-3. Waste types in brackets are expected to have been removed when the tank was sluiced in 1956.

Table D3-1. Waste Inventory of Tank 241-U-109 (Hanlon 1997).

Waste	Volume (kL)	Volume (kgal)
Sludge	182	48
Salt cake	1,499	396
Supernatant	72	19
Drainable Interstitial Liquid	617	163
Total Waste	1,753	463

Table D3-2. Expected Solids for Tank 241-U-109.

Reference	Waste type[a]
Anderson (1990)	[MW], R, CW, CW-EB, RESID, HDRL, EVAP, PNF, NCPLX
SORWT model (Hill et al. 1995)	EB, CW, R
WSTRS (Agnew et al. 1997b)	[MW], SU, SL, R, CW, EB, EF, RESID, HDRL, PNF, NCPLX
HDW model (Agnew et al. 1997a)	[MW], CWR1, SMMS1, SMMS2

CW = Cladding waste
CWR1 = REDOX cladding waste 1952 to 1960
EB = Evaporator Bottoms
EF = Evaporator feed
EVAP = Evaporator feed
HDRL = Hanford Defense Residual Liquid
MW = Metal waste
NCPLX = Non-complexed waste
PNF = Partial neutralization feed
R = REDOX HLW
REDOX = Reduction and Oxidation
RESID = Residual Liquid
SL = Slurry
SMMS1 = Supernatant mixing model, 242-S Evaporator concentrate 1973 to 1976 241-S-102 feed
SMMS2 = Supernatant mixing model, 242-S Evaporator concentrate 1977 to 1980 241-SY-102 feed
SU = Supernatant
[a]Waste types in brackets are expected to have been removed when the tank was sluiced in 1956.

Table D3-3. Hanford Defined Waste Model Solids for Tank 241-U-109 (Agnew 1997).[a]

HDW solids layer	kL	kgal
MW	91 (0)	24 (0)
CWR1	91 (132)	24 (35)
SMMS1	814 (864)	215 (228)
SMMS2	685	181

CWR1 = REDOX cladding waste 1952 to 1960
HDW = Hanford Defined Waste
MW = Metal waste
REDOX = Reduction and Oxidation
SMMS1 = Supernatant mixing model, 242-S Evaporator concentrate 1973 to 1976
241-S-102 feed
SMMS2 = Supernatant mixing model, 242-S Evaporator concentrate 1977 to 1980
241-SY-102 feed
[a] Waste volumes in parentheses are adjusted values used to calculate the best basis inventory (see Section D3.2).

D3.2 EVALUATION OF TECHNICAL FLOWSHEET INFORMATION

Tank 241-U-109 contains both salt cake and sludge. The primary waste types remaining in the tank are REDOX cladding waste 1952 to 1960 (CWR1) and evaporator bottoms (EB). Anderson (1990) and Agnew et al. (1997b) show the following chain of events:

- Tank 241-U-109 was sluiced of metal waste in 1956. Anderson (1990) indicates that the tank was empty as of the second quarter of 1956. This does not preclude the presence of a small metal waste (MW) heel. However, it is not likely.

- The tank received CWR1 supernatant in the third and fourth quarters of 1956. Anderson (1990) shows the waste type as MW in the fourth quarter of 1956. This notation is inconsistent with Anderson (1990) notes on waste additions for the third and fourth quarter of 1956. The notes indicate the addition of CW, which is consistent with subsequent waste type entries. It is presumed that the MW designation is a typographical error for CW.

- The first solids level data appears in 1965. The estimated solids volume is 132 kL (35 kgal).

- In 1969 most of the waste was sent to 241-TX-118. 2,140 kL (565 kgal) of supernatant was removed, leaving 197 kL of waste in 241-U-109. In the fourth quarter of 1969, supernatant was received from 241-U-107. The solids level was

remeasured as 182 kL (48 kgal). No further transfers occurred until 1974 when much of the waste 768 kL (263 kgal) was sent to 241-S-110.

- In the fourth quarter of 1975 tank 241-U-109 received EB from the 242-S Evaporator Crystallizer. The tank solids level was reported as 965 kL (255 kgal).

- In the first quarter of 1977, residual liquor was received. Tank 241-U-109 was declared inactive in the first quarter of 1978. At the end of 1977 the tank solids level was reported as 1,665 kL (440 kgal).

- The current solids volume reported in Hanlon (1997) is 1,681 kL (444 kgal).

With respect to tank layers defined by the HDW model, it is doubtful that the bottom layer in the tank contains any significant amount of MW. It is difficult to tell from Anderson (1990) whether EB waste was added to the tank before or after the 1969 solids level measurement. Thus the volume of CWR1 could be either 132 kL (35 kgal) or 182 kL (48 kgal). However, since the waste had sat in the tank for several years before the measurement of 132 kL (35 kgal) one could assume that the solids volume was in equilibrium with the supernatant. Because there were only minor additions before the addition of EB waste, it is probable that the solids level determination of 182 kL (48 kgal) was made after the addition of EB waste. Thus the volume of CWR1 would be 132 kL (35 kgal).

The other HDW model layers, supernatant mixing model S Evaporator 1973 to 1976 241-S-102 feed (SMMS1) and supernatant mixing model S Evaporator 1977 to 1980 241-SY-102 feed (SMMS2) correspond well with measurements of solids level made in the first quarter of 1977 and with the current volume reported by Hanlon (1997). The SMMS1 layer will need to be increased by 50 kL (13 kgal) to account for the EB waste erroneously recorded as part of the CWR1 layer.

Descriptions of the various core segments from the 1995-1996 sampling event were consistent in identifying the samples as salt cake. The samples were mostly described as being grey with some black or yellow half segments (see Table 3-2). These remarks support the conclusion that tank 241-U-109 contains little or no metal waste.

Hanlon (1997) reports a current sludge volume of 182 kL (48 kgal) for tank 241-U-109. Based on the process knowledge for this tank and the description of the core segments, there is no evidence of a sludge layer in the tank. In addition, there is no indication of a metal waste layer from examination of the core segment analytical results. The 182 kL (48 kgal) sludge volume reported by Hanlon appears to represent solids accumulated prior to 1973. These solids consist of salts precipitated from CWR1 supernatant and EB waste.

The 1988 in-tank photo montage shows the waste surface to be a mixture of liquids and solids, with orange colored salt cake floating on top of the liquid. The volume of waste in the tank has not changed since the photo was taken.

D3.3 BASIS FOR CALCULATIONS USED IN ENGINEERING ASSESSMENTS

The general approach used in this engineering assessment was to identify waste types and their approximate volumes within the tank of interest. The sources of information included analytical data from samples taken from tank 241-U-109, analytical data from other tanks containing similar waste types, and data from historical process records (Agnew et al. 1997b). The confidence level assigned to the best-basis inventory values was based on the level of agreement among the various information sources.

D3.3.1 Basis for Salt Cake Calculations Used In This Engineering Assessment

Analytical data from selected segments from tanks 241-U-109, 241-S-101, 241-S-102 and 241-U-106 were determined to be representative of SMMS1 salt cake. Analytical data from different segments from tanks 241-S-101, 241-S-102, 241-U-102, 241-U-107, and 241-U-109 were determined to be representative of SMMS2 salt cake. Analytical data for representative tanks were presented in tank characterization reports (Brown et al. 1997, Kruger et al. 1996, Eggers et al. 1996, Jo et al. 1996, Jo et al. 1997, and Hu et al. 1997).

The mean analyte concentrations for the SMMS1 and SMMS2 layers in each tank are listed in Tables D3-4 and D3-5 respectively. The SMMS1 and SMMS2 average waste concentration derived from the composite average of the tanks is also shown in Tables D3-4 and D3-5. The last column in each of these tables shows the engineering assessment-based inventory for SMMS1 and SMMS2 waste in tank 241-U-109. Where sample data were not obtained for tank 241-U-109, the average value from all of the tanks was used as the best-basis inventory for the SMMS1 or SMMS2 waste type, otherwise only the 241-U-109 sample data were used to calculate the inventory. Analyte inventory calculations for Supernate Mixing Model (SMM) waste in tank 241-U-109 were as follows:

SMMS1 (kg) = analyte concentration (μg/g) x waste volume (864 kL [228 kgal]) x density (1.67 g/mL) x conversion factors

SMMS2 (kg) = analyte concentration (μg/g) x waste volume (685 kL [181 kgal]) x density (1.67 g/mL) x conversion factors

The SMMS1 and SMMS2 average concentrations from the engineering assessment-based data were weighted based on the volume of each waste type in tank 241-U-109 to give a combined average concentration (Table D3-6). If a value was available for tank 241-U-109 it was used on the weighted average The combined average was compared with the HDW SMM concentration estimate for this tank (Table D3-5).

Table D3-4. SMMS1 Salt Cake concentrations for Representative Tanks and Best-Basis Inventory for Tank 241-U-109. (2 Sheets)

Analyte	241-S-101[a] (μg/g)	241-S-102[b] (μg/g)	241-U-106[c] (μg/g)	241-U-109[d] (μg/g)	Average[e] (μg/g)	241-U-109[f] total (kg)
Al	18,000	15,100	13,620	13,600	15,100	19,600[f]
Ag	12	17	16	NR	15	21.7
B	110	75	80	NR	88	127
Bi	71	76	<DL	<DL	74	107
Ca	273	237	336	<DL	282	407
Cl	4,500	4,100	2,930	NR	3,842	5,240[f]
Cr	10,000	4,360	3,170	4,230	5,440	6,100[f]
F	500	13,600	4,670	NR	6,255	430[f]
Fe	508	1,300	3,100	<DL	1,630	2,360
K	1,110	898	1,310	NR	1,110	1,600
Mn	266	597	1,190	NR	680	981
Na	150,000	189,000	171,000	218,000	182,000	315,000[f]
Ni	114	49	304	<DL	155	227
NO_2	91,000	40,100	56,000	42,900	57,500	61,900[f]
NO_3	110,000	99,200	147,000	297,000	163,000	428,000[f]
Pb	91	137	348	NR	192	277
PO_4	9,500	115,000	5,890	5,970	34,000	8,610[f]
P	2,290	34,000	1,950	<DL	12,700	3,060
S	5,940	2,680	3,880	NR	4,170	6,020
Si	5,270	517	176	<DL	1,990	2,870
SO_4	20,700	12,500	10,800	11,100	13,800	16,000[f]
Sr	7	<DL	<DL	NR	7	10.1
TOC	1,900	5,340	24,600	3,920	8,900	5,660[f]
U	560	1,403	781	NR	915	1,320
Zn	30	32	54	NR	39	56.3
Zr	14	39	88	NR	47	67.8
Oxalate	15,400	15,700	9,880	NR	13,700	19,600

Table D3-4. SMMS1 Salt Cake concentrations for Representative Tanks and Best-Basis
Inventory for Tank 241-U-109. (2 Sheets)

Analyte	241-S-101[a] (µg/g)	241-S-102[b] (µg/g)	241-U-106[c] (µg/g)	241-U-109[d] (µg/g)	Average[e] (µg/g)	241-U-109[f] total (kg)
Al	18,000	15,100	13,620	13,600	15,100	19,600[f]
Radio-nuclide[g]	µCi/g	µCi/g	µCi/g	µCi/g	µCi/g	kCi
^{90}Sr	252	23	77	9	90	129[f]
^{137}Cs	175	121	175	142	153	205[f]

<DL = Less than the Detectable Limit
HDW = Hanford Defined Waste
NR = Not reported
SMMS1 = Supernatant Mixing Model 242-S Evaporator salt cake generated from
1973 until 1976
[a] Kruger et al. (1996)
[b] Eggers et al. (1996)
[c] Brown et al. (1997)
[d] Appendix A
[e] Average of tank 241-S-101, 241-S-102, 241-U-106, and 241-U-109 concentrations
[f] Inventory is based on sample data for tank 241-U-109 only
[g] Radionuclides are reported as of the date of analysis.

Table D3-5. SMMS2 Salt Cake Concentrations. (2 Sheets)

Analyte	241-S-101 segments 1U-2U[a] (µg/g)	241-S-102 segments 2U-5L[b] (µg/g)	241-U-102 segments 2U[c] (µg/g)	241-U-107 segments 2U-6L[d] (µg/g)	241-U-109 segments 1L-4U[e] (µg/g)	Average concentration[f] (µg/g)	SMMS2 Salt Cake Inventory for tank 241-U-109 (kg)
Al	16,925	7,450	10,505	10,612	9,487	10,996	10,900[h]
Ag	12	17	13	16	NR	14	16.6
B	111	58	67	89	NR	81	92.7
Bi	51	<DL	<DL	270	<DL	161	184
Ca	274	233	310	298	<DL	279	319
Cl	4,607	2,981	4,550	2,515	3,560	3,643	4,170
Cr	8,163	1,577	2,417	2,570	2,570	3,459	2,940[h]
F	638	267	896	501	299	520	594
Fe	453	65	565	767	1,630	696	1,870[h]
K	1,225	748	1,360	914	NR	1,062	1,210
Mn	541	26	137	330	<DL	258	295
Na	153,000	207,000	176,000	205,667	237,333	195,800	272,000[h]
Ni	115	19	77	56	<DL	67	76.6
NO_2	58,150	28,939	36,250	27,600	42,900	38,768	44,300
NO_3	218,500	514,000	293,000	455,333	407,333	377,633	466,000[h]
Pb	66	47	<DL	149	NR	87	99.5
PO_4	9,230	15,589	19,950	13,509	5,970	12,850	14,700
P	2,333	2,860	6,187	2,580	7,780	4,348	8,900[h]
S	4,713	1,325	4,037	1,090	NR	2,791	3,190
Si	<DL	219	148	194	1,220	445	1,400[h]
SO_4	21,185	8,553	12,785	4,112	11,000	11,527	13,100
Sr	48	<DL	<DL	9	NR	28	32.0
TOC	NR	1,898	6,417	2,414	2,330	3,265	3,260
U	1,497	<DL	<DL	430	<DL	964	1,100
Zn	33	21	33	29	NR	29	33.2
Zr	13	<DL	<DL	13	NR	13	14.9

Table D3-5. SMMS2 Salt Cake Concentrations. (2 Sheets)

Analyte	241-S-101 segments 1U-2U[a] (µg/g)	241-S-102 segments 2U-5L[b] (µg/g)	241-U-102 segments 2U[c] (µg/g)	241-U-107 segments 2U-6L[d] (µg/g)	241-U-109 segments 1L-4U[e] (µg/g)	Average concentration[f] (µg/g)	SMMS2 Salt Cake Inventory for tank 241-U-109 (kg)
Radionuclide[g] (Ci)							kCi
^{90}Sr	252	NR	<DL	0.297	4.81	86	5.72[h]
^{137}Cs	160.15	NR	136.5	62.06	89.1	112	102[h]

<DL = Less than detectable limit

HDW = Hanford Defined Waste

NR = Not reported

SMMS2 = Supernatant Mixing Model 242-S Evaporator salt cake generated from 1977 until 1980

[a] Kruger et al. (1996)

[b] Eggers et al. (1996)

[c] Hu et al. (1997)

[d] Jo et al. (1996)

[e] Appendix A

[f] Average of tank 241-S-101, 241-S-102, 241-U-102, 241-U-107, and 241-U-109 concentrations

[g] Radionuclides are reported as of the date of sample analysis

[h] Inventory is based on sample data for tank 241-U-109 only.

Table D3-6. Tank 241-U-109 SMM Average Concentration Comparisons. (2 Sheets)

Analyte	241-U-109 SMMS1 and SMMS2 weighted average (µg/g)	HDW model SMM for 241-U-109 (average) µg/g
Al	11,800	33,100
Ag	15.0	NR
B	84.9	NR
Bi	112.5	176
Ca	278	999
Cl	3,600	6,380
Cd	17.6	NR
Cr	3,720	5,690
F	3,720	786

Table D3-6. Tank 241-U-109 SMM Average Concentration Comparisons. (2 Sheets)

Analyte	241-U-109 SMMS1 and SMMS2 weighted average ($\mu g/g$)	HDW model SMM for 241-U-109 (average) $\mu g/g$
Fe	1,640	467
K	1,090	1,900
Mn	493	165
Na	226,000	248,000
Ni	117	278
NO_2	40,600	84,000
NO_3	346,000	219,000
Pb	146	149
PO_4	9,010	6,090
P	4,620	NR
S	3,560	NR
Si	1,650	1,670
SO_4	11,350	17,500
Sr	16.3	0
TOC	3,630	1,050
U	937	1,720
Zn	34.6	NR
Zr	32.0	13.8
Oxalate	10,380	3.68
Radionuclides	$\mu Ci/g$[a]	$\mu Ci/g$
^{90}Sr	7.23	95.2
^{137}Cs	119	201

HDW = Hanford Defined Waste - Agnew et al. (1997[a]) radionuclides decayed to January 1, 1994.

NR = Not reported

SMM = Supernatant mixing model

SMMS1 = Supernatant mixing model, 242-S Evaporator concentrate 1973 to 1976 241-S-102 feed

SMMS2 = Supernatant mixing model, 242-S Evaporator concentrate 1977 to 1980 241-SY-102 feed

[a] Radionuclides are reported as of the date of the sample analysis.

D3.3.2 Basis for Sludge Calculations Used In This Engineering Evaluation

The CWR Sludge concentrations used in this engineering assessment were developed with analytical data for tanks 241-U-109, 241-S-102, 241-S-104, and 241-S-107 (Appendix A, Eggers et al. 1996, Jo et al. 1997, S-107). While CWR1 waste may be intermixed in tank 241-U-109, the same situation applies in the tanks used to predict the CWR waste concentration. Thus, the CWR waste is probably a mixture including some CWR and REDOX process salt cake (R SltCk) waste. Data were selected based on Agnew et al. (1997) predicted sludge location. The average concentrations from each tank and the segments used in the calculation are shown in Table D3-7. Where sample data for 241-U-106 an analyte was not available, the overall mean from several tanks was averaged to estimate the concentration and inventory in the CWR waste. The HDW model values for CWR1 sludge and inventory estimates are also listed in Table D3-7. Analyte inventory calculations for CWR sludge in tank 241-U-109 were as follows:

CWR (kg) = analyte concentration (μg/g) x waste volume (132 kL) x density (1.57 g/mL) x conversion factors

Table D3-7. Tank 241-U-109, Sludge Calculations. (2 Sheets)

Analyte	241-U-109[a] (Bottom 1) (μg/g)	241-S-104[b] (all) (μg/g)	241-S-107[c] (Bottom 3) (μg/g)	241-S-101[d] (Bottom 2) (μg/g)	Average (μg/g)	HDW[e] CWR1 (μg/g)	Sludge Inventory for tank 241-U-109[c] (kg)
Al	52,700	117,000	56,400	127,000	88,300	171,000	10,900[f]
Bi	NR	<45.7	NR	<38.8	<42.2	0	<8.74
Ca	NR	247	234	322	268	2,730	55.5
Cl	NR	3,200	1,860	2,050	2,370	141	491
Cr	2,450	2,350	1,180	2,230	2,050	59.8	507[f]
F	NR	145	150	<65.7	148	0	30.6
Fe	2,360	1,720	1,160	1,960	1,800	5,200	489[f]
Hg	NR	<0.126	NR	NR	<0.126	0	<0.126
K	NR	300	457	539	432	33.0	89.4
La	NR	<2.07	NR	<19.5	<10.8	0	<10.8
Mn	244	1,150	83	2,750	1,057	0	50.5[f]
Na	133,000	121,000	60,400	112,000	107,000	102,000	27,600[f]
Ni	NR	56	206	90.7	118	33.7	24.4
NO$_2$	NR	25,900	34,300	31,100	30,400	24,900	6,300

Table D3-7. Tank 241-U-109, Sludge Calculations. (2 Sheets)

Analyte	241-U-109[a] (Bottom 1) (μg/g)	241-S-104[b] (all) (μg/g)	241-S-107[c] (Bottom 3) (μg/g)	241-S-101[d] (Bottom 2) (μg/g)	Average (μg/g)	HDW[e] CWR1 (μg/g)	Sludge Inventory for tank 241-U-109[f] (kg)
NO_3	41,500	191,000	57,600	119,000	102,000	20,000	8,600[f]
Pb	NR	29.6	33	37	33.2	13,800	6.87
PO_4	NR	<2,190	1,630	1,360	1,730	0	357
P	NR	93.2	391	278	254	NR	52.6
S	NR	472	293	343	369	NR	76.4
Si	3,060	1,330	1,060	1,360	1,700	NR	634[f]
SO_4	NR	2,270	1,300	897	1,490	455	308
Sr	NR	424	378	456	419	0	86.7
TIC as CO_3	NR	4,140	NR	NR	4,140	0	858
TOC	3,740	1,730	NR	NR	2,735	0	775[f]
U	NR	6,690	8,690	7,684	7,690	NR	1,593
Zn	NR	20.1	24	25.1	23.1	NR	4.78
Zr	NR	33.6	131	36	66.9	0	13.8
density (g/mL)	1.57	1.74	1.87	1.74	1.73	1.77	1.57[f]
Radio-nuclides[g]	μCi/g	μCi/g	μCi/g	μCi/g	μCi/g	μCi/g	kCi
^{137}Cs	68.8	60.5	74	98	75.3	1.33	14.2[f]
^{90}Sr	NR	301	276	NR	288	1.16	59.7

CWR = REDOX cladding waste 1952 to 1960
HDW = Hanford Defined Waste, CWR concentration (for comparison only).
[a] Appendix A
[b] DiCenso et al. (1994)
[c] Statistically determined median R1 sludge concentrations for tank 241-S-107 contained in the attachment to Simpson et al. (1996)
[d] Kruger et al. 1996
[e] Agnew et al. 1997a
[f] Inventory is based on sample data for tank 241-U-109 only.
[g] Radionuclides are reported as of the sample analysis date.

D3.3.3 Inventory Comparisons

Table D3-8 contains the total engineering assessment-based inventories calculated by summing the four waste layer inventories to produce the tank inventory.

Table D3-8. Tank 241-U-109 Engineering Assessment Total Inventory Calculations.
(2 Sheets)

Element	241-U-109 SMMS1 Salt cake (kg)	241-U-109 SMMS2 Salt cake (kg)	241-U-109 CWR (kg)	241-U-109 supernatant[a] (kg)	Tank total (kg)
Al	19,600	10,900	10,900	409	41,800
Bi	107	184	<8.74	NR	300
B	127	92.7	9.56	3.17	232
Ca	407	319	55.5	NR	772
Cl	5,240	4,170	491	256	10,200
Cr	6,100	2,940	507	9.20	9,560
F	1,480	594	30.6	21.5	2,130
Fe	2,360	1,870	489	NR	4,720
Pb	277	99.5	6.87	NR	383
Mn	987	295	50.5	NR	1,330
Ni	227	76.6	24.4	NR	328
NO_3	428,000	466,000	8,590	25,800	928,000
NO_2	61,900	44,300	6,300	3,090	116,000
PO_4	8,610	14,700	357	430	24,100
P	3,060	8,900	52.6	60.4	12,100
K	1,600	1,220	89.4	NR	2,900
Si	2,870	1,400	634	4.10	4,910
Ag	21.7	16.60	2.01	NR	39.7
Na	315,000	271,000	27,600	12,700	626,000
Sr	10.1	32.0	86.7	NR	129
SO_4	16,000	13,100	308	799	34,200
S	6,020	3,190	76.4	NR	9,280
TOC	5,660	3,260	775	168	9,860
U	1,320	1,100	1,593	NR	4,013

Table D3-8. Tank 241-U-109 Engineering Assessment Total Inventory Calculations.
(2 Sheets)

Element	241-U-109 SMMS1 Salt cake (kg)	241-U-109 SMMS2 Salt cake (kg)	241-U-109 CWR (kg)	241-U-109 supernatant[a] (kg)	Tank total (kg)
Zn	56.3	33.2	4.78	NR	94.3
Zr	67.8	14.9	13.8	NR	96.5
Oxalate	19,600	7,100	NR	NR	26,700
Density (g/mL)	1.67	1.67	1.57	NR	NR
Radionuclides (Ci)					
^{137}Cs	205,000[b]	102,000[b]	14,200[c]	NR	321,000
^{90}Sr	12,900[b]	5,720[b]	59,700[c]	NR	78,300

CWR = Cladding waste REDOX

NR = Not reported or not detected

SMMS1 = Supernatant mixing model, 242-S Evaporator concentrate 1973 to 1976 241-S-102 feed

SMMS2 = Supernatant mixing model, 242-S Evaporator concentrate 1977 to 1980 241-SY-102 feed

[a] Calculated using liquid values from Appendix A

[b] Radionuclides reported as of the sample analysis date

[c] Radionuclides reported as of January 1, 1994.

The engineering assessment-based inventory values, the sample-based inventories, and the HDW model values are compared in Table D3-9.

Table D3-9. Comparison of Selected Component Inventory Estimates for Tank
241-U-109 Waste. (2 Sheets)

Component	Engineering assessment (kg)	Sample-based (kg)	HDW estimated (kg)[a]
Al	41,800	57,700	121,000
Bi	300	<6,180	499
Ca	772	<6,180	3,580
Cl	10,200	NR	18,100
CO$_3$	NR	110,000	68,100

Table D3-9. Comparison of Selected Component Inventory Estimates for Tank
241-U-109 Waste. (2 Sheets)

Component	Engineering assessment (kg)	Sample-based (kg)	HDW estimated (kg)[a]
Cr	9,560	10,800	16,200
F	2,130	NR	2,230
Fe	4,720	<4,160	2,760
K	2,900	NR	5,400
Mn	1,330	<632	467
Na	626,000	647,000	712,000
Ni	328	<1,230	798
NO_2	116,000	NR	242,000
NO_3	928,000	9.02 E+05	626,000
Oxalate	26,700	NR	10.5
Pb	383	NR	2,640
PO_4	24,100	<71,700	20,700
SO_4	34,200	NR	50,500
Sr	129	NR	0
Si	4,910	<3,370	4,800
TOC	9,860	10,500	29,800
U	4,013	1,250	46,700
Zr	96.5	NR	39.1
^{90}Sr	78,300	20,200	271,000
^{137}Cs[b]	321,000	328,000	570,000
H_2O (percent)	NR	24	22.2

HDW = Hanford Defined Waste
NR = Not reported or not detected
[a] Agnew et al. (1997a)
[b] Radionuclides are reported as of the sample analysis data.

D3.4 INDEPENDENT EVALUATION OF TANK SAMPLE INFORMATION

Between December 20, 1995 and January 19, 1996 three core samples from three separate risers were obtained and analyzed. Each core sample consisted of 9 segments. Sample recovery for segments 1 through 5 was about 45 percent and between 70 and 100 percent for segments 6 through 9.

Four analytical results were reported for sodium. These were fusion digest results on segments, water digest results for a limited number of segments, fusion digest composite core sample results and water digest composite core sample results. In general, water digest samples are preferred over fusion digest results for sodium. The water digest core sample results may be biased since they were based on a limited number of segments. Therefore, the inventory based on water digest composite core samples (647,000 kg) was considered to be the most appropriate value.

Three analytical results were reported for uranium, inductively coupled plasma (ICP) analyzed core sample segments, ICP analyzed composite core samples, and uranium phosphorescence analyzed composite core samples. Uranium phosphorescence has a lower detection limit than ICP for uranium and is used for the best-basis inventory.

Most analytical results reported in Table D2-1 were based on fusion digested samples.

D3.5 DOCUMENT ELEMENT BASIS

This section compares the engineering assessment-based inventory to the inventory estimate calculated by the HDW model (Agnew et al. 1997a). In general, the HDW model estimate may be higher because it was derived using a density of 1.8 g/mL, as compared to engineering assessment and sample-based inventories that used 1.67 g/mL for salt cake and 1.57 for sludge. In addition, the HDW model is based on 182 kL (48 kgal) of sludge and 814 kL (215 kgal) of SMM1 salt cake, as compared to 132 kL (35 kgal) of sludge and 864 kL (228 kgal) of SMM1 salt cake that was used for the engineering assessment. The HDW may also be biased by the solubility assumptions in the HDW model.

Aluminum. The estimates derived from the core samples, and the HDW model estimate for aluminum were 57,700 kg, and 121,000 kg respectively. Differences may be due to solubility assumptions in the HDW model and higher volumes of sludge predicted in the HDW model. The aluminum concentration in CWR1 samples was four and a half times greater than in salt cake samples (compare Table D3-6 and D3-7).

Bismuth. 241-U-109 sample results were below detection levels for this analyte. The estimated inventory derived from sample results for tanks with similar waste types and the HDW model estimate were 300 kg and 499 kg respectively. Bismuth concentrations were two and a half times lower in sludge samples than in salt cake. Sample concentrations for sludge and salt cake waste were similar to HDW model estimates.

Calcium. 241-U-109 sample results were below detection limits for this analyte. The estimated inventory derived from sample results for tanks with similar waste types and the HDW model estimate were 772, and 3,580 kg respectively. Differences may be due primarily to solubility assumptions in the HDW model.

Iron. 241-U-109 sample results for the SMM1 waste type were below detection limits for this analyte. The estimated inventory derived from sample results for tanks with similar waste types and the HDW model estimate were 4,720, and 2,760 kg respectively. Differences may be due primarily to solubility assumptions in the HDW model.

Manganese. 241-U-109 sample results were below detection limits for this analyte. The estimated inventory derived from sample results for tanks with similar waste types and the HDW model estimate were 1,330, and 467 kg respectively. The HDW model uses a concentration of "0" for CWR1 waste. This may account for some of the difference between the two values.

Total Hydroxide. Once the best-basis inventories were determined, the hydroxide inventory was calculated by performing a charge balance with the valences of other analytes. In some cases this approach requires that other analyte (e.g., sodium or nitrate) inventories be adjusted to achieve the charge balance. During such adjustments the number of significant figures is not increased. This charge balance approach was consistent with that used by Agnew et al. (1997a).

Silicon. 241-U-109 sample results were below detection limits for this analyte. The estimated inventory derived from sample results for tanks with similar waste types and the HDW model estimate were 4,910 and 4,800 kg respectively.

Sulfate. 241-U-109 sample results were not reported for this analyte. The estimated inventory derived from sample results for tanks with similar waste types and the HDW model estimate were 34,200 and 50,500 respectively.

Phosphate. The estimate derived from the engineering assessment and the HDW model estimate for phosphate were 24,100 kg and 20,700 kg respectively. Minor differences are likely due to differences in sample density used for the two calculations.

Uranium. 241-U-109 sample results were below detection limits for this analyte. The estimated inventory derived from core sample results for tanks with similar waste types and the HDW model estimate were 4,070 and 46,700 kg respectively. Uranium concentrations are approximately 10 times higher in sludge waste than in salt cake waste. The lower volume of sludge used in engineering assessments would account for some of the difference. Solubility assumptions in the HDW model may also bias results.

D4.0 DEFINE THE BEST-BASIS AND ESTABLISH COMPONENT INVENTORIES

Information about chemical, radiological, and/or physical properties is used to perform safety analyses, engineering evaluations, and risk assessment associated with waste management activities, as well as regulatory issues. These activities include overseeing tank farm operations and identifying, monitoring, and resolving safety issues associated with these operations and with the tank wastes. Disposal activities involve designing equipment, processes and facilities for retrieving wastes and processing them into a form that is suitable for long-term storage.

Chemical and radiological inventory information are generally derived using three approaches: (1) component inventories are estimated using the results of sample analyses, (2) component inventories are predicted using the HDW Model based on process knowledge and historical information, or (3) a tank-specific process estimate is made based on process flowsheets, reactor fuel data, essential material usage, and other operating data.

An effort is underway to provide waste inventory estimates that will serve as standard characterization source terms for the various waste management activities (Hodgson and LeClair 1996). As part of this effort, an evaluation of available information for tank 241-U-109 was performed including the following:

1. Analytical results from segmented core samples from three different risers were used to estimate the component inventories. However, detection limits were high and many analytes, generally found in similar waste types, were not detected.

2. Where samples were not available results of an engineering assessment based on sample data from several tanks with similar waste types were used.

3. Sample-based and engineering-based inventories were compared with HDW model estimates.

The inventory values reported in Tables D4-1 and D4-2 are subject to change. Refer to the Tank Characterization Database (TCD) for the most current inventory values.

Best-basis inventory estimates for tank 241-U-109 are presented in Tables D4-1 and D4-2. The projected inventory is based on a sample-based inventory and engineering evaluation of the tank. The radionuclide inventories shown in Table D4-2 are based on the 1995 to 1996 core sample results decayed to January 1, 1994, and HDW model estimates.

Table D4-1. Best-Basis Inventory Estimates for Nonradioactive Components in
Tank 241-U-109 (Effective May 31, 1997). (2 Sheets)

Analyte	Total inventory (kg)	Basis (S, M, E, or C)[1]	Comment
Al	57,700	S	
Bi	300	E	
Ca	772	E	
Cl	10,200	E	
TIC as CO_3	110,000	S	
Cr	10,800	S	
F	2,130	E	
Fe	4,720	E	
Hg	77.9	M	
K	2,900	E	
La	12.6	M	
Mn	1,330	E	
Na	647,000	S	core composite water digest analysis
Ni	328	E	
NO_2	116,000	E	
NO_3	928,000	E	
OH	206,000	E/C	Based on charge balance
Pb	383	E	
P as PO_4	24,100	E	
Si	4,910	E	
S as SO_4	34,200	E	
Sr	129	E	
TOC	9,860	E	
U_{TOTAL}	1,250	S	core composite phosphorescence analysis

Table D4-1. Best-Basis Inventory Estimates for Nonradioactive Components in
Tank 241-U-109 (Effective May 31, 1997).   (2 Sheets)

Analyte	Total inventory (kg)	Basis (S, M, E, or C)[1]	Comment
Zr	96.5	E	

[1]S = Sample-based

M = Hanford Defined Waste model-based, Agnew et al. (1997a)

E = Engineering assessment-based.

Table D4-2. Best-Basis Inventory Estimates for Radioactive Components in
Tank 241-U-109, Decayed to January 1, 1994 (Effective May 31, 1997). (2 Sheets)

Analyte	Total inventory (Ci)	Basis (S, M, or E)[1]	Comment
^{3}H	559	M	
^{14}C	82.6	M	
^{59}Ni	5.14	M	
^{60}Co	504	M	
^{63}Ni	92.2	M	
^{79}Se	8.06	M	
^{90}Sr	82,400	E	
^{90}Y	82,400	E	Determined from ^{90}Sr value.
^{93}Zr	39.5	M	
^{93m}Nb	28.7	M	
^{99}Tc	586	M	
^{106}Ru	0.0167	M	
^{113m}Cd	209	M	
^{125}Sb	399	M	
^{126}Sn	12.2	M	
^{129}I	1.13	M	
^{134}Cs	6.04	M	
^{137}Cs	339,000	E	
^{137m}Ba	321,000	E	Determined from ^{137}Cs value.
^{151}Sm	28,400	M	
^{152}Eu	9.6	M	
^{154}Eu	1,490	M	
^{155}Eu	569	M	
^{226}Ra	3.46 E-04	M	
^{227}Ac	2.14 E-03	M	
^{228}Ra	0.280	M	
^{229}Th	6.62 E-03	M	
^{231}Pa	9.79 E-03	M	

Table D4-2. Best-Basis Inventory Estimates for Radioactive Components in
Tank 241-U-109, Decayed to January 1, 1994 (Effective May 31, 1997). (2 Sheets)

Analyte	Total inventory (Ci)	Basis (S, M, or E)[1]	Comment
^{232}Th	0.0188	M	
^{232}U	1.49	M	
^{233}U	5.71	M	
^{234}U	15.6	M	
^{235}U	0.691	M	
^{236}U	0.166	M	
^{237}Np	2.12	M	
^{238}Pu	5.65	M	
^{238}U	16.0	M	
$^{239/240}$Pu	258	M	
^{240}Pu	39.8	M	
^{241}Am	135	M	
^{241}Pu	355	M	
^{242}Cm	0.368	M	
^{242}Pu	1.80 E-03	M	
^{243}Am	4.95 E-03	M	
^{243}Cm	0.0342	M	
^{244}Cm	0.338	M	

[1]S = Sample-based
 M = Hanford Defined Waste model-based, Agnew et al. (1997a)
 E = Engineering assessment-based.

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